United States Patent [19]

Schlotfeldt

[11] **3,909,982**

[45] **Oct. 7, 1975**

[54] **APPARATUS FOR PRODUCING CONTACT LENSES**

[75] Inventor: **Walter A. Schlotfeldt,** Addison, Ill.

[73] Assignee: **Med-Con Engineering,** Chicago, Ill.

[22] Filed: **Sept. 4, 1973**

[21] Appl. No.: **394,326**

Related U.S. Application Data

[62] Division of Ser. No. 188,714, Oct. 13, 1971, Pat. No. 3,763,597.

[52] **U.S. Cl.** **51/58;** 51/284; 82/12

[51] **Int. Cl.²** **B24B 13/00;** B23B 5/40

[58] **Field of Search** ..... 82/12; 51/58, 33 W, 284

[56] **References Cited**

UNITED STATES PATENTS

1,309,264	7/1919	Squier	51/58 UX
1,408,305	2/1922	Maynard	82/12
2,237,744	4/1941	Mullen	82/12 X
2,435,212	2/1948	Golden	82/12
2,554,530	5/1951	Hosinski	82/12
2,568,040	9/1951	Touvay	51/58
3,079,732	3/1963	Rawston	51/58
3,221,577	12/1965	Baum	82/12

Primary Examiner—Donald G. Kelly

Attorney, Agent, or Firm—George H. Gerstman

[57] **ABSTRACT**

Apparatus for producing contact lenses, in which the cutting tool for cutting the base curve into a contact lens blank pivots about a point that is movable to vary the radius of curvature of the cutting tool, without moving the relative positions of the cutting tool tip and the blank. The blank with the base curve cut thereon is conveyed to supporting means so that the base curve will be polished as it faces upwardly. The lens blank is held by vacuum means during cutting of the power curve, and the power curve is polished with a wood polishing device.

4 Claims, 26 Drawing Figures

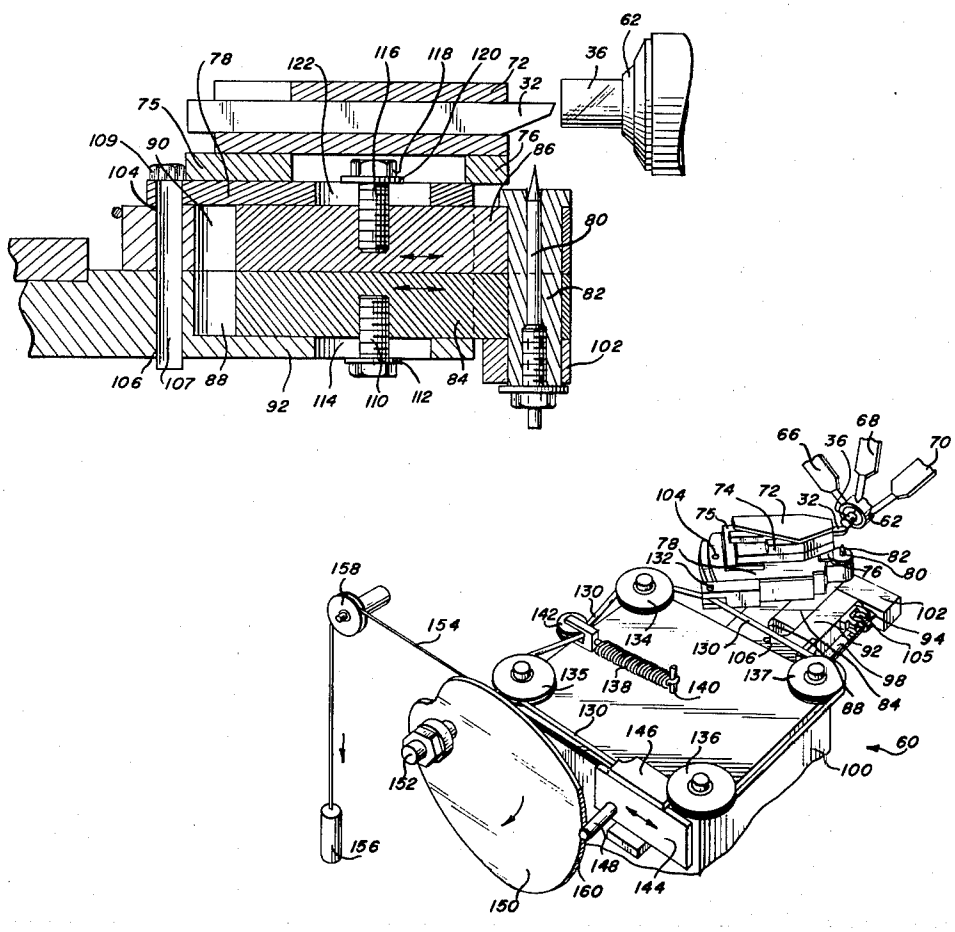


FIG. 1

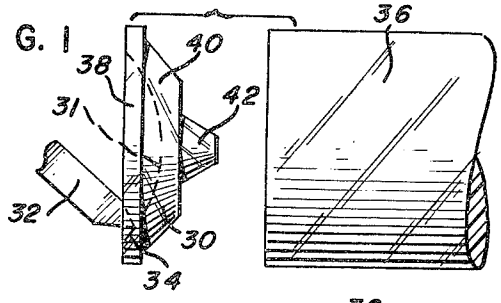


FIG. 2

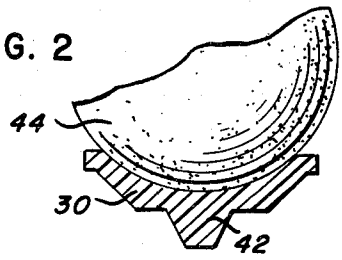


FIG. 3

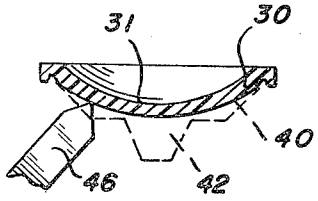


FIG. 4

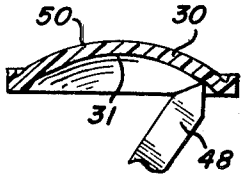


FIG. 6

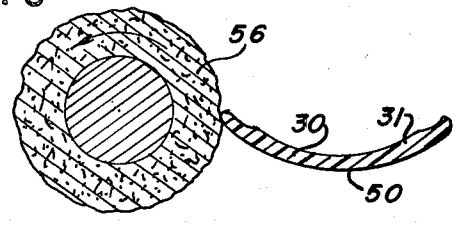


FIG. 5

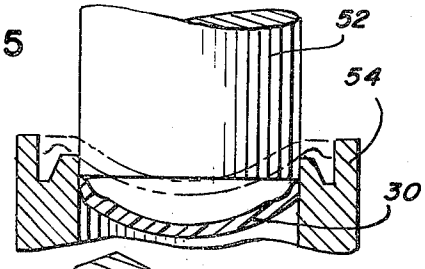


FIG. 7

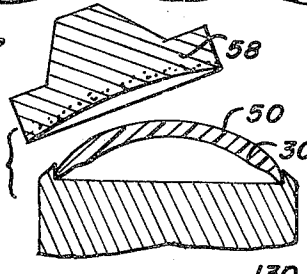


FIG. 8

FIG. 9

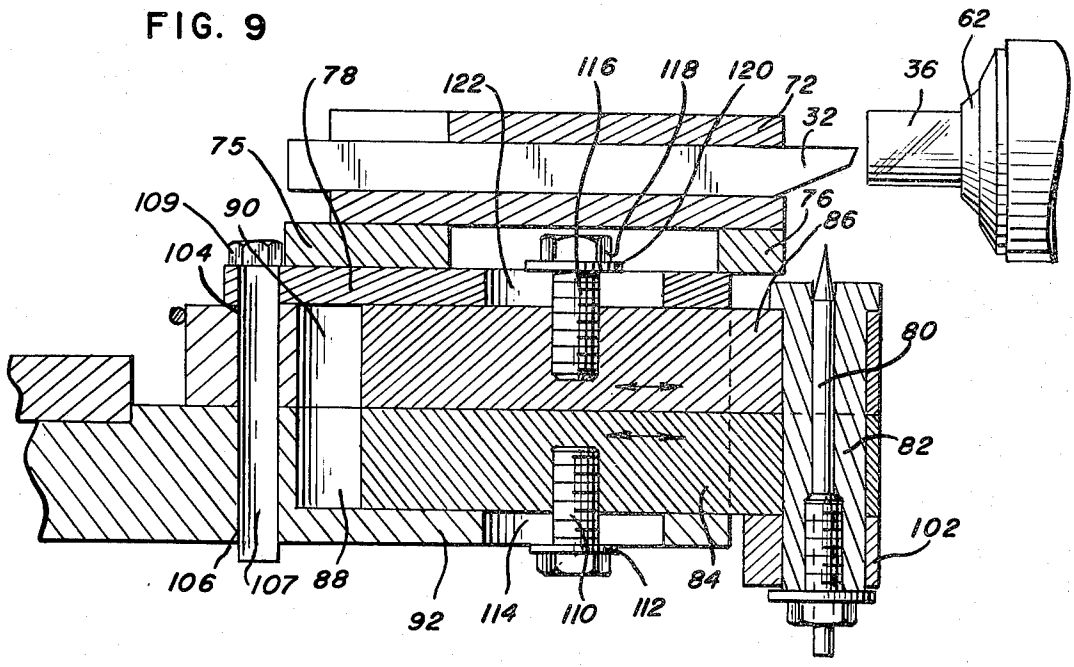

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FIG. 10

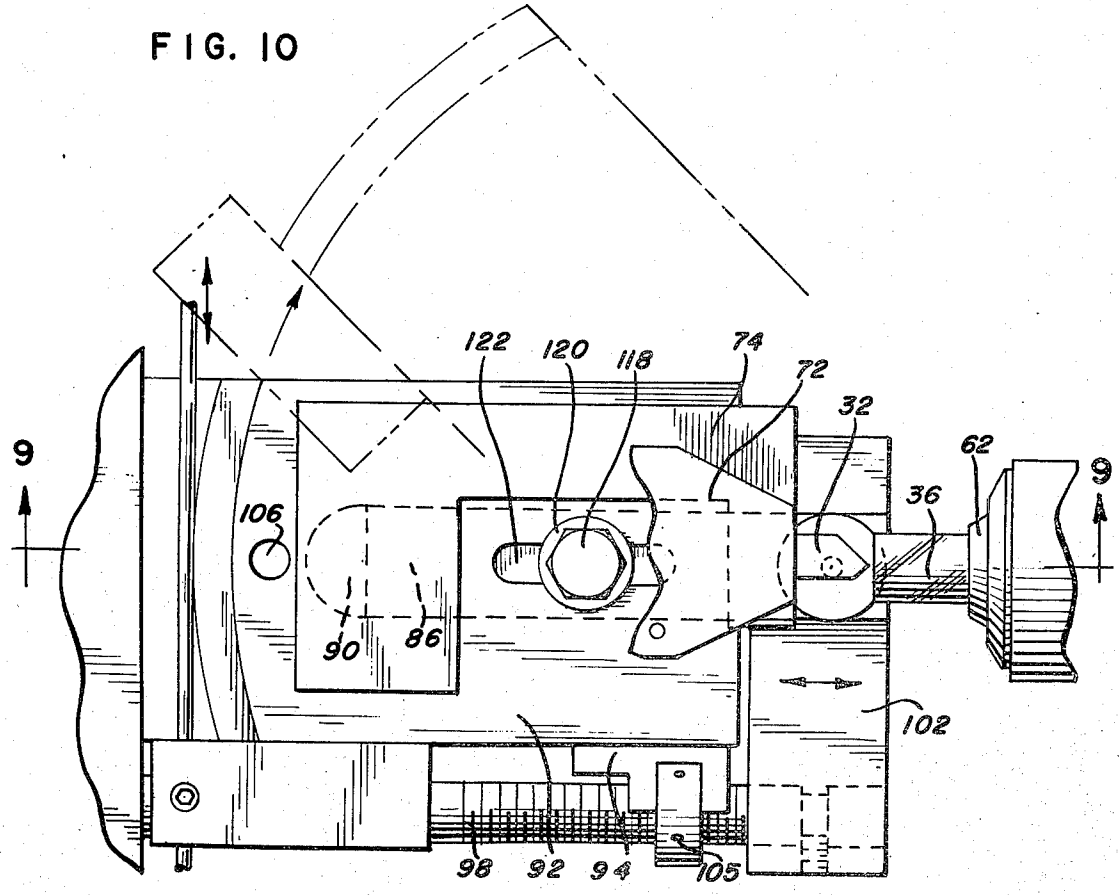
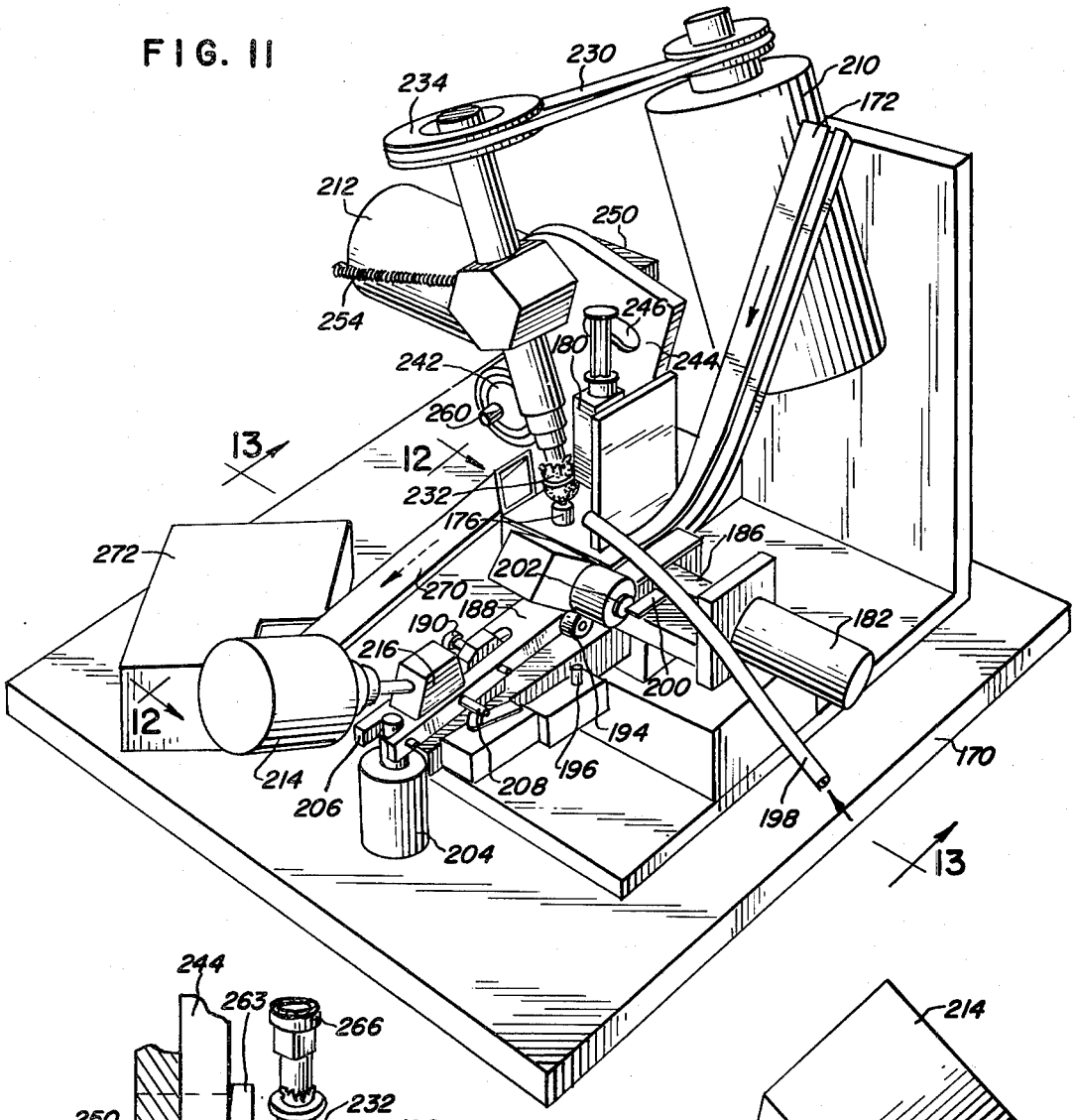

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FIG. 11


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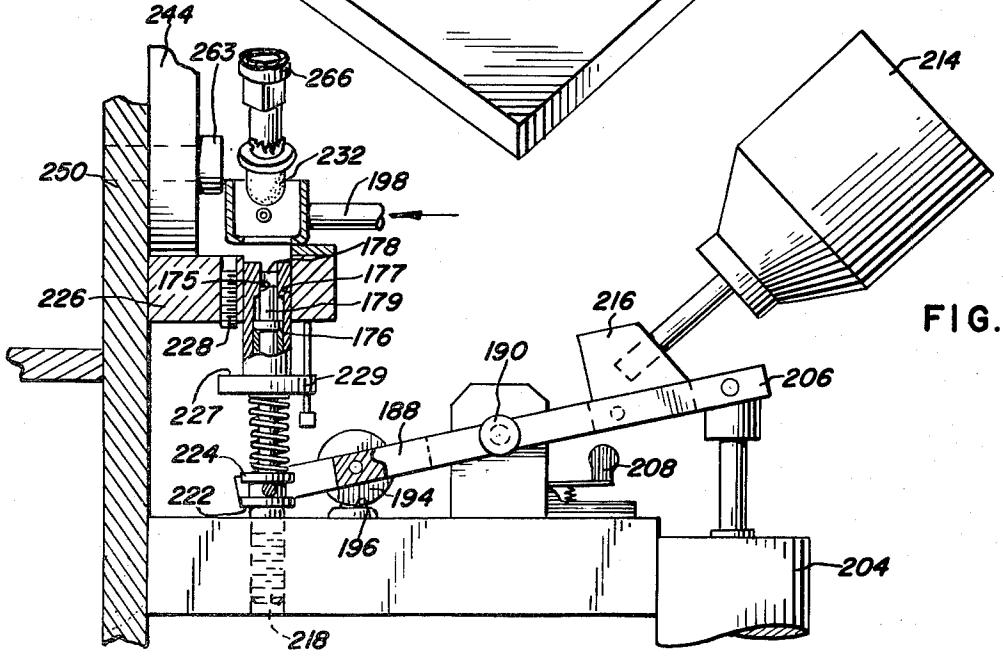

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FIG. 12

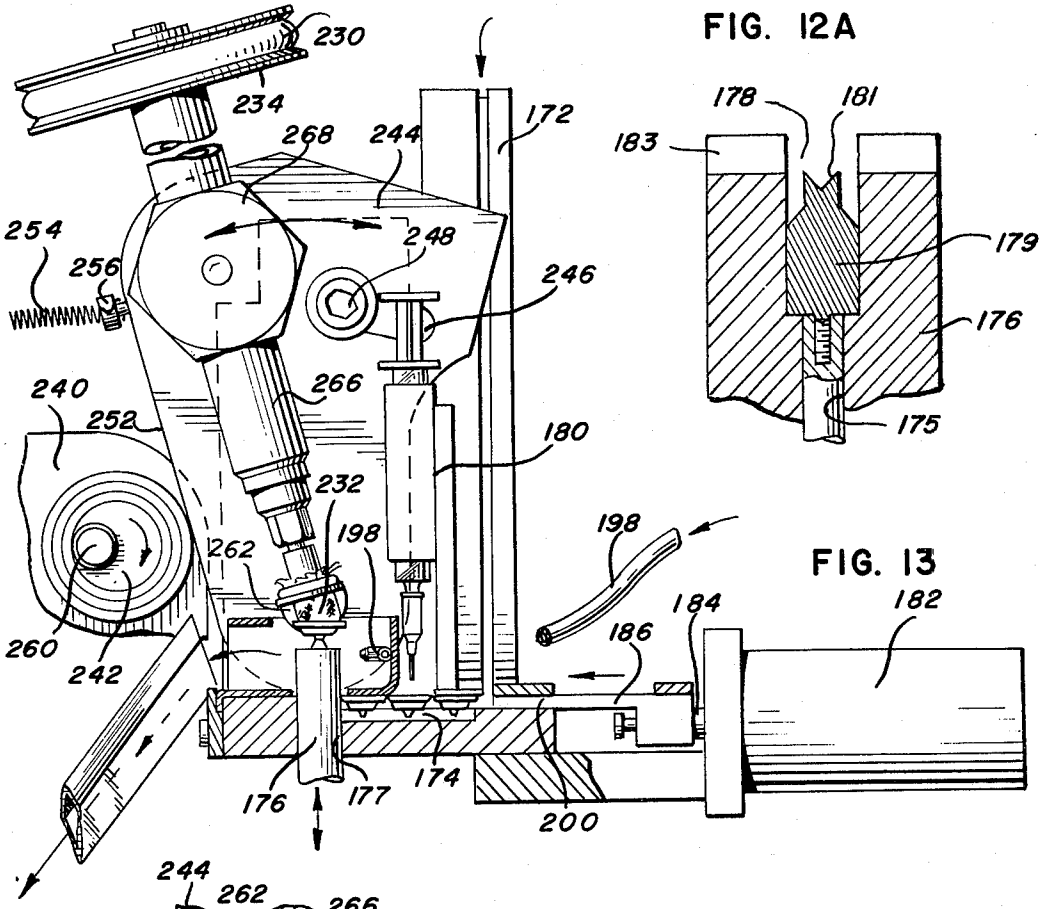


FIG. 12A

FIG. 13

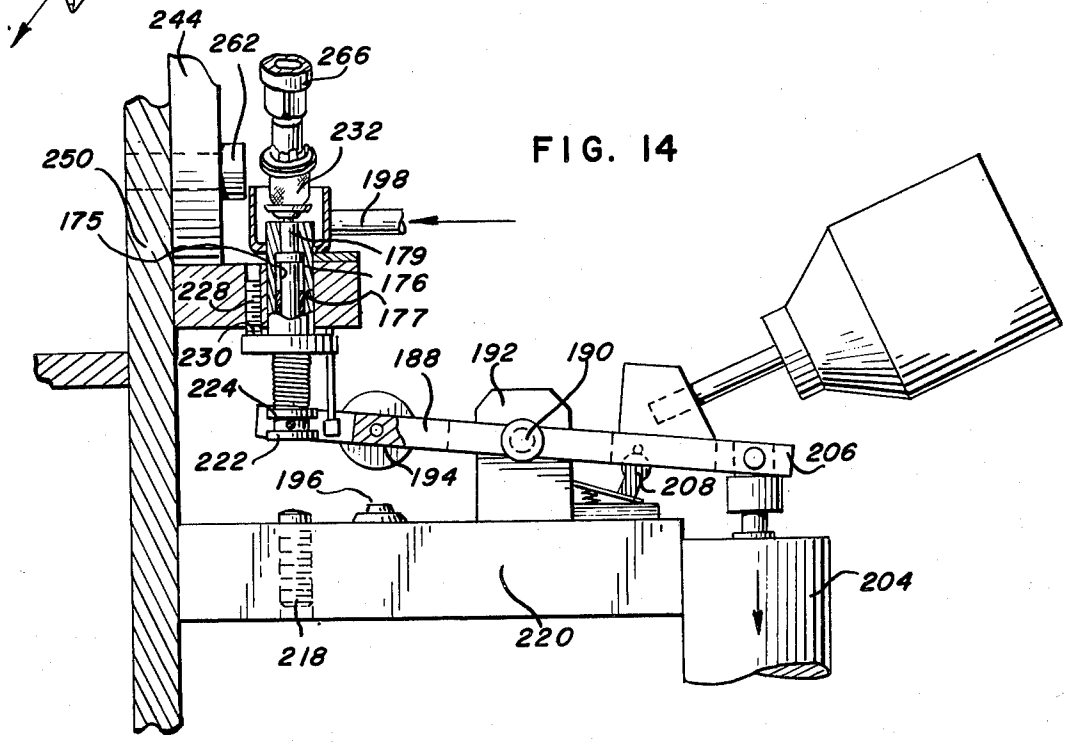


FIG. 14

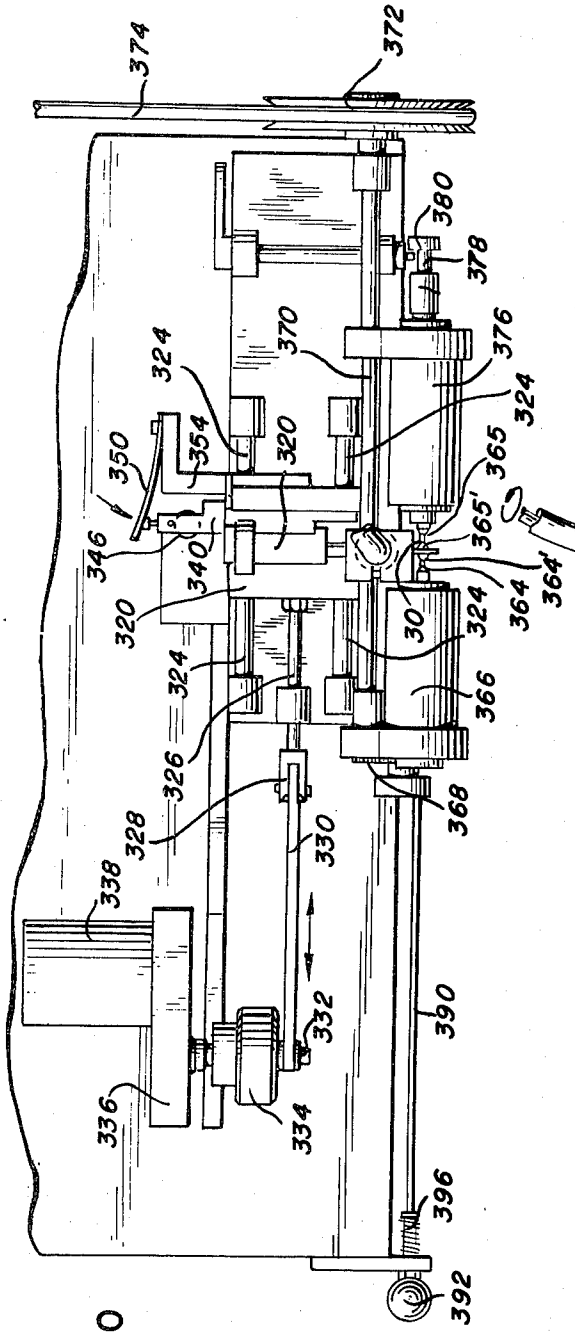

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FIG. 20

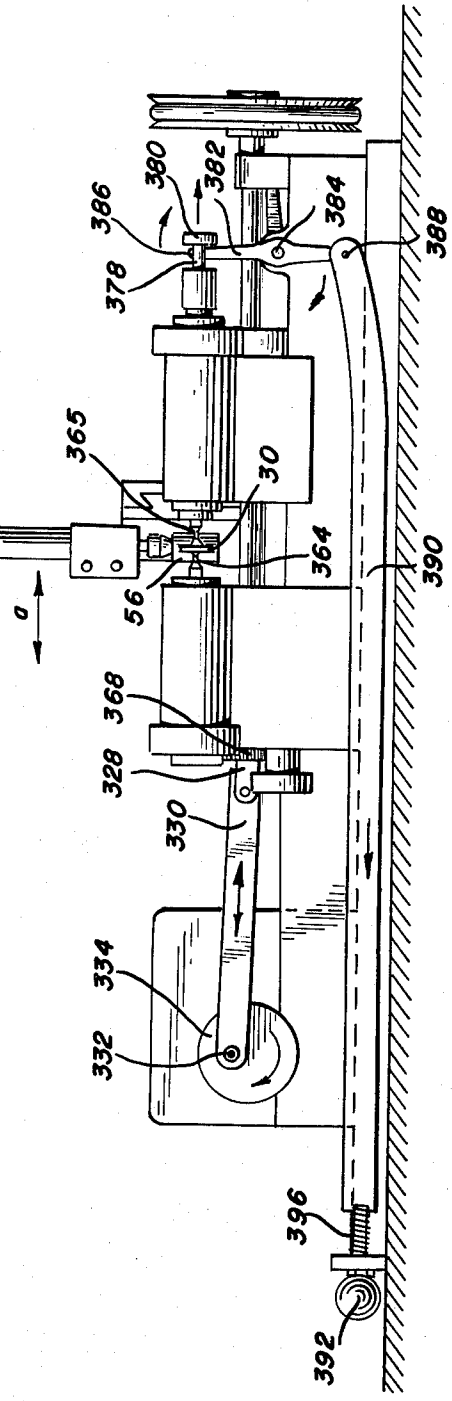

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FIG. 21

FIG. 15

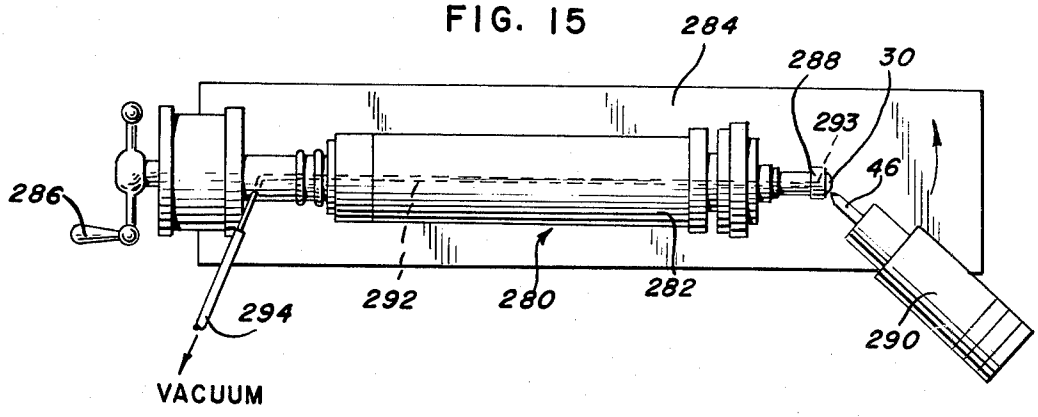


FIG. 16

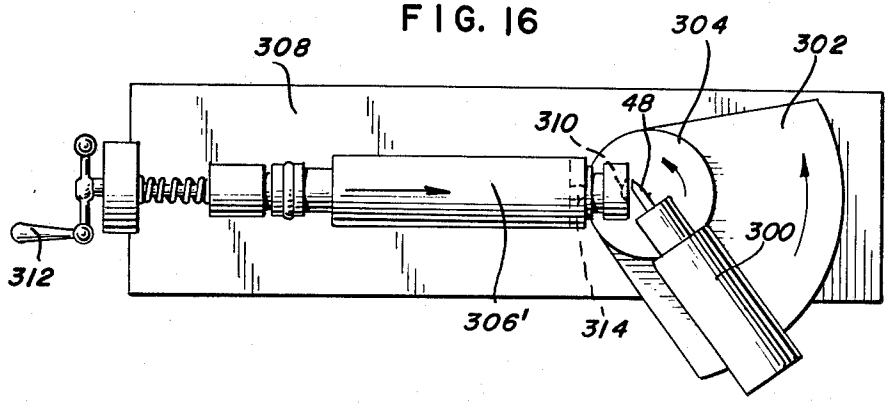


FIG. 18

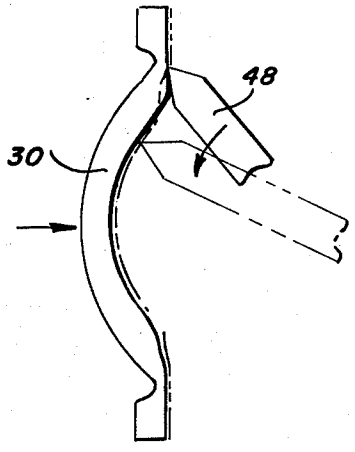


FIG. 17

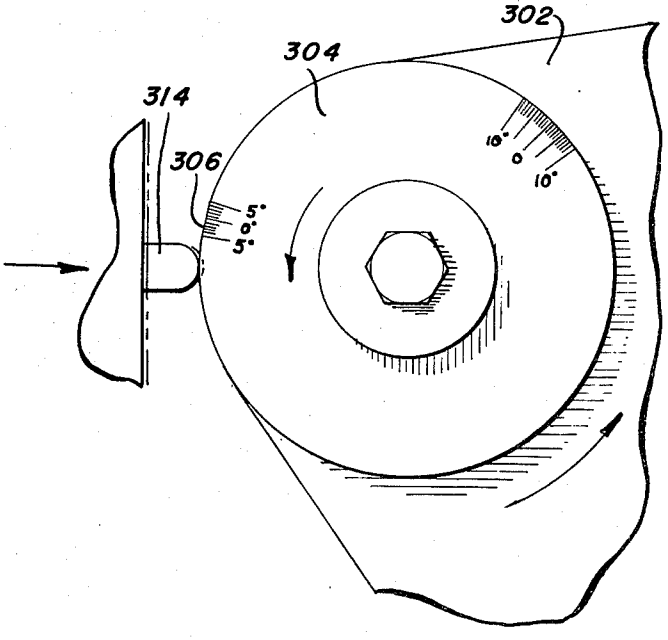


FIG. 19

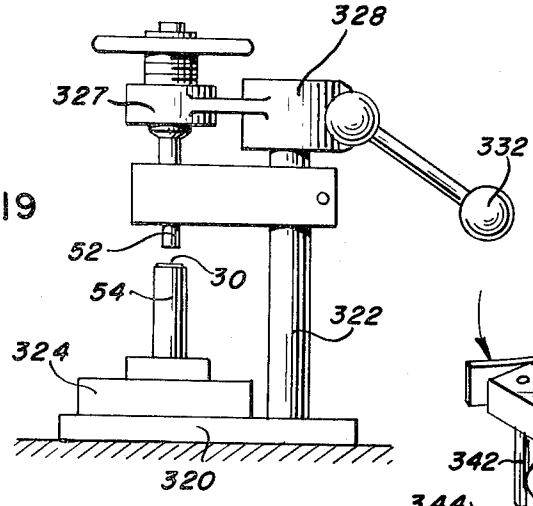


FIG. 22

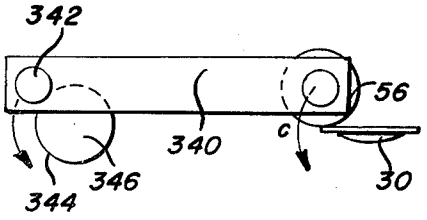


FIG. 23

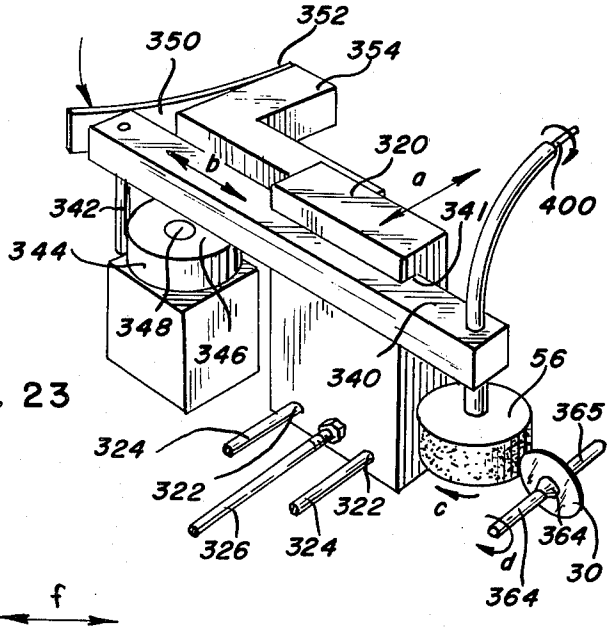


FIG. 24

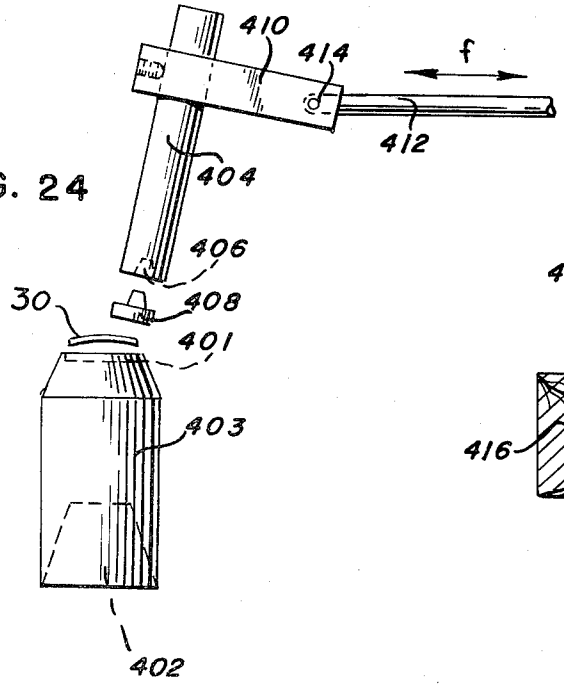
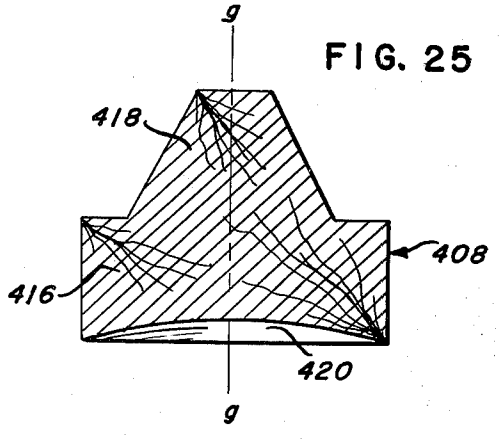


FIG. 25



APPARATUS FOR PRODUCING CONTACT LENSES

This is a division of application Ser. No. **188,714,** filed Oct. **13, 1971,** now U.S. Pat. No. **3,763,597.**

BACKGROUND OF THE INVENTION

The present invention relates to an improved apparatus for producing contact lenses.

Contact lenses are generally produced by utilizing precision tools to cut both surfaces of the lens and polishing the lens. Contact lenses have been fabricated by molding techniques, but molding of such lenses has been found disadvantageous primarily because of warping problems.

In the prior art fabrication of contact lenses using precision tooling techniques, a plastic lens blank, in the form of a disc, is provided. The posterior or base curve is generated on the blank with a diamond cutting tool and is cupped out to substantially the outer dimension of the disc. The base curve is then polished and, subsequently, the anterior or power curve is cut on the other side of the blank with a diamond cutting tool, according to a prescription. The power curve is polished and, subsequently, a peripheral curve and an intermediate peripheral curve are cut by a diamond cutting tool. The peripheral curves are buffed to complete the lens.

In cutting the base curve using prior art techniques, it is generally necessary to measure the depth of the curve (from the nadir of the curve to the plane in which its circumference lies) each time the radius of the base curve is changed. This is because in order to vary the radius of the base curve, the diamond cutting tool is moved and hence the depth is changed.

One embodiment of the present invention concerns an apparatus which permits the radius of the base curve to be changed without varying the depth of the base curve. In order to achieve this result, the pivot point upon which the diamond cutting tool pivots is moved with respect to the diamond tool without moving the relative positions of the cutting tool tip and the blank. In this manner, the depth will not vary, although the radius of curvature of the base curve can be varied as desired.

Using typical prior art fabrication techniques, the lens blank having the base curve cut therein is then manually inserted into a collect and a rotating polishing tool is brought into engagement with the curved surface. Typically the polishing head extends upwardly and the lens blank is brought downwardly against it by a polishing machine which pivots the lens blank while the polishing head is rotating. It is apparent that manual insertion of the lens blank into the collet is necessary using prior art techniques and it is difficult to apply any polishing compound to the base curve which faces downwardly. In one embodiment of the present invention, an automatic base curve polishing apparatus is provided which feeds the lens blank (having the base curve cut therein) to a platform where the base curve faces upwardly and a downwardly facing polishing tool is utilized for engaging the base curve. After the blank is polished, it is automatically ejected into an appropriate receptacle.

In order to avoid substantial manual processing of the lens blank, it is desirable that the lens blank be other than a typical disc. In one embodiment of the present invention, there is provided a lens blank which comprises a generally disc-shaped member formed of plastic material having a base curve on one side thereof and a central protuberance extending from the other side thereof. The central protuberance is useful in enabling apparatus to engage and maintain in place the lens blank for processing by the apparatus of the present invention, without the necessity of substantial manual handling.

The delicate fitting of a lens blank into a collet which holds the lens blank during the cutting of the power curve by a diamond cutting tool is time consuming and deleterious to an efficient operation. Therefore, in one form of the present invention, the apparatus which holds the lens blank during cutting of the power curve comprises vacuum means which has an outlet nozzle for communication with the base curve side of the lens blank. In this manner, an evacuated volume is formed and defined by the nozzle and the concavity of the base curve, thereby retaining the lens blank in position against the nozzle during cutting of the power curve.

From the foregoing, it can be seen that an object of the present invention is to provide apparatus for fabricating contact lenses in a manner which requires relatively little manual handling and is substantially automated.

Other objects and advantages of the present invention will become apparent from the following description, claims and drawings.

BRIEF DESCRIPTION OF THE INVENTION

In the illustrative embodiment, the base curve of a contact lens blank is cut by positioning the cutting tip of a cutting tool at a predetermined location with respect to the blank. Means are provided for pivoting the cutting tool about a pivot point and means are provided for moving the pivot point to vary the radius of curvature of the cutting tool tip without moving the relative positions of the cutting tool tip and the blank.

In one form of the invention, the contact lens blank comprises a generally disc-shaped member formed of plastic material and having a base curve on one side thereof and a central protuberance extending from the other side thereof.

In the illustrative embodiment, the base curve is polished by providing means for underlying and supporting the contact lens blank with the base curve facing upwardly. Rotating polishing means for polishing the base curve include a downwardly extending polishing tool for engaging the base curve. Means are provided for conveying the lens blank to the supporting means, which supporting means includes a vertically movable pedestal within a channel with a conveyor being positioned to convey a lens blank to the channel whereupon the blank will overlie the pedestal.

In cutting the power curve in accordance with the principles of the present invention, vacuum means are provided for holding the lens blank during the power curve cutting, with the vacuum means having an outlet nozzle for communication with the base curve side of the lens blank so that an evacuated volume is formed and defined by the nozzle and the concavity of the base curve, thereby retaining the blank in position against the nozzle during cutting of the power curve.

In accordance with the illustrative embodiment, the power curve is polished by a porous, relatively soft member, such as a wood member having a polishing surface conforming to the shape of the power curve and essentially consisting of wood being porous enough

to become at least partially receptive to a liquid polishing compound.

In accordance with the present invention, the peripheral curve is cut utilizing a rotating base member with a tool holder located on the base member. Means are provided for permitting movement of the lens blank holder in a lateral direction, and camming means are carried by the base member for camming the holder to move in the lateral direction, during a portion of rotation of the base member, to cut the peripheral curve in a predetermined manner. The width and radius of the peripheral curve are selected according to known physiologic criteria. The peripheral curve can have a single radius or an aspheric radius.

The edge of a substantially finished lens is polished in accordance with the principles of the present invention, by apparatus which includes means for holding the contact lens at its central portion on both sides thereof, with the holding means being rotated during polishing. A cylindrical polishing member is provided and is rotatable about an axis perpendicular to the axis of the holding means. Means are provided for moving the polishing member back and forth in an arcuate manner about the edge of the lens.

A more detailed explanation of the invention is provided in the following description and claims, and is illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1–7 are diagrammatic views of the various steps in fabricating a contact lens in accordance with the principles of the present invention;

FIG. 8 is a fragmentary, perspective view of a base curve cutting apparatus in accordance with the principles of the present invention;

FIG. 9 is an enlarged, cross-sectional elevation of a portion thereof;

FIG. 10 is a top plan view of the device of FIG. 9;

FIG. 11 is a perspective view of a base curve polishing apparatus constructed in accordance with the principles of the present invention;

FIG. 12 is an enlarged, fragmentary view thereof, taken along the line 12—12 of FIG. 11 (with the pedestal in its lowered) position);

FIG. 12A is a greatly enlarged, fragmentary, cross-sectional view of the pedestal lift of the FIG. 11 apparatus;

FIG. 13 is an enlarged, fragmentary view thereof, taken along the line 13—13 of FIG. 11;

FIG. 14 is an enlarged, fragmentary view thereof, taken along the line 12—12 of FIG. 11 (with the pedestal in its raised position);

FIG. 15 is a diagrammatic view of apparatus for cutting the power curve of a contact lens blank in accordance with the principles of the present invention;

FIG. 16 is a diagrammatic view of apparatus for cutting the peripheral curve of a lens blank in accordance with the principles of the present invention;

FIG. 17 is an enlarged, fragmentary view of a portion of the apparatus of FIG. 16;

FIG. 18 is a diagrammatic view of the cutting of the peripheral curve utilizing the apparatus of FIG. 16;

FIG. 19 is an elevational view of a punch constructed in accordance with the principles of the present invention;

FIG. 20 is a top plan view of apparatus for polishing the lens edge of a substantially finished lens blank in accordance with the principles of the present invention;

FIG. 21 is a side elevational view thereof;

FIG. 22 is a diagrammatic view of the polishing portion thereof;

FIG. 23 is a diagrammatic view of the mechanism for moving the polishing wheel in the apparatus of FIG. 20;

FIG. 24 is a diagrammatic view of apparatus for polishing the power curve in accordance with the principles of the present invention; and

FIG. 25 is an enlarged view of the wood polishing member for polishing the power curve in accordance with the principles of the present invention.

DETAILED DESCRIPTION OF THE ILLUSRATIVE EMBODIMENT

Referring to the drawings, FIG. 1 shows a lens blank 30 having a base curve 31 cut by means of cutting tool 32 having a diamond tip 34. Lens blank 30 is cut from plastic rod 36, as will be described below, and comprises a generally disc-shaped member having a peripheral rim 38, an inclined body portion 40, and a central extending protuberance 42. A cross-sectional view of the lens blank 30 is shown in FIG. 2.

FIG. 2 shows lens blank 30 being polished by member 44, while FIG. 3 shows the cutting of the power curve on the lens blank. In FIG. 3 there is shown a schematic representation of a cutting tool 46 cutting the power curve on a lens blank 30, which blank originally takes the configuration shown in dashed line and which is reduced to the configuration shown in full line.

The schematic representation shown in FIG. 4 is a cutting tool 48 cutting the peripheral curve on lens blank 30, in which the power curve 50 and the base curve 31 have already been cut. After the peripheral curve is formed, referring to FIG. 5, the lens blank 30 is cut by means of a suitable cutting device employing movable punch 52 and stationary die 54, to cut a selected portion off the lens blank. The power curve 50 of blank 30 is polished by a suitable polishing member 58, as shown schematically in FIG. 7, and the edge of the lens is then polished by a rotating member 56, as schematically shown in FIG. 6.

THE BLANK FORMING APPARATUS (FIGS. 8–10)

An apparatus generally referred to by reference numeral 60 and illustrated in FIGS. 8–10, is utilized to form a lens blank in accordance with the principles of the present invention. Apparatus 60 includes a bushing 62 through which a rod 36 is advanced. Rod 36 is formed of a suitable plastic material, as is well-known in the art, for forming contact lenses. Rod 36 is advanced in predetermined increments and is acted upon by a trio of tool members 66, 68 and 70 to form rim 38, inclined portion 40, and projection 42, as most clearly shown in FIG. 1. Tools 66, 68 and 70 are programmed to operate upon rod 36 after the base curve 31 has been cut by tool 32.

Tool 32 is clamped by means of a tool holder including an upper plate 72 and a lower plate 74 which are connected to pedestals 75 and 76 which pedestals are fastened to and ride with pivotal base member 78. Base member 78 is pivotable about pivot pin 80 which can be moved laterally with respect to base member 78, as will be explained below.

Pivot pin 80 is fastened by suitable fastening means, such as a threaded member and nut arrangement (as shown in FIG. 9), to pivot carrier 82 which pivot car-

rier is fastened to lower slider **84.** Pivot carrier **82** is also fastened to upper slider **86.** Sliders **84** and **86** are adapted to slide within their respective slots **88** and **90** when bolts **110** and **116** are loosened. Slot **88** is defined by member **92** which is fixed and carries a thumb-wheel holder **94.** Slot **90** is defined by member **78.**

A threaded rod **98** is fastened between main drive support member **100** and slider drive member **102.** Threaded member **98** carries a thumb-wheel **105** thereon which, when turned, moves member **102** which is fastened to slider **84.** However, member **102** cannot move unless bolt **110** is released.

In order for pivot pin **80** to be moved while tool **32** remains stationary, sliders **86** and **84** must be aligned. To accomplish alignment of sliders **86** and **84,** member **78** defines an aperture **104** while member **92** defines an aperture **106.** When apertures **104** and **106** are aligned, a pin **107** having, a bolt-head **109** can be inserted therein to couple the apertures and sliders **86** and **84** will be in alignment to allow thumb-wheel **105** to be turned, thereby moving member **102** to move the sliders **86, 84** and the attached pivot pin **80.**

In order to prevent movement of tool **32** and its connected structure **72, 74, 75, 76** and **78** with respect to slider **86,** a bolt **116** threadedly engages slider **86** with the head **118** of bolt **116** lying within the opening defined by pedestals **75, 76** and clamping a washer **120** against an upper wall of member **78** which defines a slot **122** in member **78.** Further, to prevent movement of members **102** and **92** with respect to slider **84,** a bolt **110** threadedly engages lower slide **84** and clamps a washer **112** against an undersurface of member **92** defining a slot **114** in member **92.** It can thus be seen that in order for sliders **86, 84** to slide within slots **90, 88,** it will be necessary to loosen bolts **116, 110** to release the washers **120, 112** from clamping engagement with the surfaces defining slots **122, 114.**

In order for member **78** carrying tool **32** to pivot about pin **80,** in a manner so that tool **32** oscillates in a predetermined mode to cut the base curve **31** on rod **36,** a driving system is carried by member **100.** The driving system comprises a wire **130** which is fastened to member **78** by fastening means **132** and which engages the outside of pulleys **134, 135, 136** and **137,** which pulleys are rotatably fastened to member **100.** Tension is provided on wire **130** by means of a tension spring **138** which is affixed to member **100** at **140** and which biases the underside of a pulley **142** against wire **130.**

An oscillating follower **144** is positioned adjacent member **100** and is fastened to wire **130** by flange **146** so that oscillation of follower **144** will cause equivalent movement of wire **130.** Follower **144** carries an extending pin **148** which engages the surface of eccentric cam **150** having a shaft **152** eccentrically located with respect to the cam and which shaft is driven by a suitable electric motor. A wire **154** is connected at one end thereof to follower **144** and has a weight **156** connected to the other end thereof, with the wire **154** being drawn over a fixed pulley **158.** Wire **154** and its associated weight **156** are utilized to bias folower **144** and its associated pin **148** against the end surface of cam **150,** as shown in FIG. **7.** Hence pin **148** will tend to follow surface **160** of cam **150,** thereby forcing follower **144** to oscillate thereby inducing equivalent oscillation in member **78.**

It can be seen that the point about which tool **32** pivots can be moved without changing the distance between the tip of tool **32** and the end surface of rod **36.** To move pivot **80,** member **78** is pivoted so that hole **104** aligns with hole **106** and a pin is inserted therein to maintain member **78** in fixed arrangement with member **92.** Bolts **110** and **116** are loosened and thumb-wheel **105** can then be turned to move sliders **84** and **86** together, with their associated pivot carrier **82,** thereby changing the pivot of tool **32.** When pivot **80** is in the proper position, bolts **110** and **116** are retightened, the pin is removed from holes **104, 106** and cam **150** can be driven to oscillate holder **78** with respect to member **92** and with respect to the workpiece rod **36** while rod **36** is rotating. After a predetermined number of oscillations cause the base curve **31** to be cut into rod **36,** tools **66, 68** and **70** will operate upon rod **36** to form blank **30,** inclined portion **40** and projection **42,** and to sever the formed lens blank **30** from the remaining portion of the rod within the chuck **62.** The lens blank **30** is now ready for the base curve to be polished.

BASE CURVE POLISHING APPARATUS (FIGS. 11–14)

An automatic apparatus for polishing the base curve of a lens blank is illustrated in FIGS. **11–14.** The apparatus is mounted on a base **170** and includes a chute **172** into which are placed a number of lens blanks **30** with the base curve facing the upper surface of the chute **172.** Lens blanks **30** drop to a support **174** where several blanks are aligned for positioning onto movable pedestal **176** which rides within a channel **177.** When pedestal **176** is in its lower position, it permits a lens blank **30** to be located thereon with the projection **42** of the lens blank lying within a recess **178** defined by the pedestal at its top surface thereof and centrally located therewith. Pedestal **176** defines a central bore **175** through which a movable rod **179** extends. Referring to FIG. **12A,** the top of movable rod **179** has an indent **181** to receive projection **42** of lens blank **30.** When pedestal **176** is in its lowered position, blank **30** is pushed through groove **183** defined by the pedestal to the center position, overlying rod **179.** When the pedestal is raised, rod **179** is raised further to engage projection **42** and to place lens blank **30** directly under the polishing head.

Prior to being forced onto platform **176,** a predetermined amount of polishing compound is directed onto the unpolished base curve of the lens blank by means of an automatically actuated hypodermic-type syringe **180,** most clearly shown in FIG. **13.** Syringe **180** is adjusted to provide a certain number of drops of polishing compound per minute, and is synchronized with the movement of the blanks, which movement is timed.

The apparatus includes a piston device **182,** the rod **184** of which is fastened to an arm **186** which operates to force a blank onto pedestal **176** when the pedestal is in its downward position. To actuate piston device **182,** pedestal **176** is coupled to a lever **188** which pivots about pin **190** connected to standard **192** so as to cause member **194** to engage contact **196** when pedestal **176** is in its downward position. When member **194** engages contact **196,** a circuit is completed so that air hose **198** is operated thereby blowing a lens blank off pedestal **176** and piston device **182** is actuated so that arm **186** will force another lens blank onto the lowered pedestal **176.**

Referring to FIG. 11, it is seen that a laterally extending element 200 is connected to arm 186 so that once the arm has been extended to force a lens blank onto pedestal 176, element 200 will engage contacts 202 of a switch to operate a solenoid 204 thereby pulling downwardly the distal end 206 of lever 188 and causing the pedestal 176 and its associated rod 179 to be raised to the position shown in FIG. 14, in contrast to its lower position as shown in FIG. 12. When the lever is lowered, it will engage microswitch 208 to operate main polishing motor 210 and rocking motor 212. Lever 188 carries a counterbalancing weight 214 which is fastened to a standard 216 affixed to lever 188.

Referring to FIG. 14, it is seen that a set screw 218 is carried by base member 220 to engage the underside 222 of member 224 located at the bottom of pedestal 176, thereby limiting the downward travel of the pedestal 176. Referring to FIG. 12, it is seen that extension 226 carries a set screw 228 the bottom of which is engaged by top surface 227 of collar 229 of limit the upward movement of pedestal 176, although rod 179 will continue to move upwardly until the base curve of the lens blank engages the polishing head.

Polishing motor 210 drives a belt 230 which turns a polishing head 232 through the action of pulley 234. Polishing head 232 engages the base curve of lens blank 30 which lies upon rod 179 and the head 232 is caused to rock back and forth with respect to the stationary lens blank by means of motor 212 which operates through a gear reducer 240 to drive an eccentric cam 242, thereby providing rocker action. Referring to FIG. 13 in particular, it is seen that a rocker panel 244 defines a slot 246 through which bolt 248, connected to stationary plate 250, moves. The end 252 of rocker panel 244 is biased in the leftward direction (with respect to FIG. 13) by means of spring 254 connected between fastening member 256 and motor 212, to urge end 252 against the surface of cam 242. It can be seen that when the cam is in the position shown in FIG. 13 (with the greatest radial distance between pivot 260 and the cam end being toward rocker panel 244) rocker member 244, which rocks about pivot 262, is in its most rightward position (with respect to FIG. 13). Since polishing head 232 is connected to tool 266 which is rigidly fastened to the rocker panel 244 by connector 268, such camming will cause polishing head 232 to oscillate with oscillation of rocker panel 244.

After a predetermined time period has elapsed, pedestal 176 and its associated rod 179 will be lowered until member 194 engages contact 196, air will be forced through tube 198 to blow lens blank 30 (which is upon pedestal 176) into exit tube 270 which gravity-feeds the lens blank 30 having a polished base curve to a receptacle 272. Piston device 182 is actuated to force another lens blank 30 onto the lowered pedestal and, when extension 200 carried by arm 186 engages contact 202, solenoid 204 will be actuated to raise pedestal 176 so as to put the new unpolished lens blank into engagement with polishing head 232. Engagement of lever 188 with microswitch 208 once the pedestal is in its upper position will actuate motors 210 and 212 to commence the polishing and rocking operation.

POWER CURVE FORMING APPARATUS (FIG. 15)

The power curve is cut on the lens blank by removing inclined portion 40 and projection 42 as shown in FIG. 3. Referring to FIG. 15, a cutting tool 46 is positioned adjacent a lens blank holding mechanism 280. Holding mechanism 280 comprises a cylinder 282 that is linearly movable with respect to platform 284 by turning handle 286, so as to place the lens blank 30 held by member 288 in a desired position with respect to tool 46. Tool 46 is carried by a tool holder 290 which pivots so as to cause tool 46 to cut a predetermined curve on the anterior surface of lens blank 30.

Cylinder 282 has a tube 292 running centrally therethrough with one end 293 of tube 292 communicating with member 288 and another portion 294 of tube 292 extending to a vacuum pump. In this manner, air at member 288 is evacuated through tube 292 when the vacuum pump is operated, to create a vacuum at the outlet of member 288 so that the base curve surface of lens blank 30 can be sucked against member 288 to thereby retain lens blank 30 in place for cutting the power curve, without the need to fasten the lens blank to the interior of a collect member which is often time consuming and burdensome. Hence when the power curve is to be generated on the lens blank, the lens blank is simply brought against member 288 with the base curve surface of the lens blank 30 facing member 288. The concavity of lens blank 30 in communication with the evacuated volume inside member 288 will provide a strong holding force for the lens blank against member 288 during the generation of the power curve.

PERIPHERAL CURVE GENERATOR (FIG. 16–18)

A peripheral curve generating system is shown generally in FIG. 16. The peripheral curve is generated by cutting at the extremities of the base curve with a cutting tool 48, which cutting tool is grasped by a tool holder 300 that is fastened to a motor driven pivoting platform 302. A cam 304 having a camming surface 306 is affixed to the forward edge of the platform. Surface 306 is flattened and rounded in a predetermined manner so as to cam the lens blank into a predetermined relationship with the cutting tool 48 during pivoting of the cutting tool.

To this end, a blank holding member 306′ which is movable laterally with respect to its platform 308 is provided for holding the lens blank during the peripheral curve cutting operation. Lens blank 30 is grasped by a suitable collet located within member 310 and member 306′ is moved by turning handle 312 so that the lens blank is positioned in a selected location with respect to cutting tool 48. I have discovered that, if desired, the lens blank 30 can be held, during the peripheral curve cutting operation, with a vacuum holding device similar to that used in the power curve cutting operation of FIG. 15. Vacuum holding can be accomplished because of the surface provided by the underside of rim 38.

A cam follower 314 is fastened to the underside of member 306 so that member 306′ will move laterally (to the left and right with respect to FIG. 16) in conformance with the action of follower 314 engaging surface 306 of cam 304.

It can be seen that as tool holder 300 is pivoted so as to inscribe a peripheral curve upon lens blank 30, surface 306 will engage follower 314 to move member 306′ in a predetermined manner during pivoting of lens holder 300, thereby generating a peripheral curve in a selected mode. The peripheral curve generating apparatus of the present invention has been found to be extremely useful when generating peripheral curves

which include an outside peripheral curve and an intermediate peripheral curve. Such complex configurations are in wide use in the contact lens art.

PUNCHING OF LENS BLANK (FIG. 19)

After generating the peripheral curve, the lens blank is punched to remove an area of the blank adjacent its periphery. A typical punch is shown in FIG. **19** and includes a base **320** supporting an upright **322** and also supporting a platform **324** with blank holder **52** attached to platform **324.** A punch press head **327** extends from slider **328** which is movable with respect to standard **322,** but is keyed at a desired height to maintain head **327** in place with respect to punch **52.** Head **327** has a downwardly extending die **54** extending therefrom which is shaped so as to punch lens blank **30** in a desired manner to remove a peripheral portion of the blank therefrom. The punch is operated in a manner well-known in the prior art, by moving handle **332** to lower punch **54** into engagement with and through lens blank **30.**

After the blank is punched, the peripheral curve is polished with a soft Velveteen pad and a polishing compound as is known in the art. The power curve is then polished, as described below, and the edge of the lens is polished as described immediately below.

CONTACT LENS EDGING APPARATUS (FIGS. 20–23)

An apparatus is provided for polishing the edge (the plastic surface between the base curve and the power curve) of a contact lens blank, which apparatus includes a cylindrical polishing wheel **56** that rotates about an axis that is perpendicular to the axis of rotation of a contact lens blank **30.** Polishing wheel **56** is carried by an assembly which moves the axis of polishing wheel **56** in an arcuate manner, as shown in FIG. **22,** so that wheel **56** will polish around the entire periphery of lens blank **30.**

In order for the axis of wheel **56** to obtain an arcuate movement, it is necessary to provide simultaneous bidirectional force components in the directions of arrows *a* and *b* of FIG. **23,** during rotation of wheel **56** (in the direction of arrow *c*) and rotation of lens blank **30** (in the direction of arrow *d*).

Movement in the direction of arrow *a* (FIG. **23**) is accomplished by moving the holder **320** defining a pair of apertures **322** which allow holder **320** to slide along rods **324** as a result of the force applied against holder **320** in the direction of arrows *a* by means of rod **326** which is affixed to holder **320.** Referring to FIG. **20,** rod **326** is coupled through a pivotable linkage **328** to crank **330** which is pivotally and eccentrically connected at **332** to rotating member **334.** Rotating member **334** is coupled through gear reducer **336** to an electric motor **338** to drive crank **330** and thereby move holder **320** in the direction of arrows *a.*

To obtain movement of wheel **56** in the direction of arrows *b,* the wheel **56** is fastened to a bar **340** which dovetails at **341** within a slot defined by holder **320** to form a crank-type arrangement. A downwardly extending pin **342** engages the end surface **344** of a wheel **346,** which wheel **346** has an eccentric pivot **348** causing wheel **346** to cam pin **342** in the direction of arrows *b.* Pin **342** is biased against surface **344** by means of a leaf spring **350** which is fastened at one end **352** to member **354,** with member **354** being affixed to holder **320.** It can thus be seen that when motor **338** is operating and wheel **346** is turning, polishing wheel **56** will be moved in an arcuate direction because of the orthogonal force components exerted against it in the directions of arrows *a* and *b.*

Lens blank **30** is held between two rotatable shafts **364, 365** which have resilient cup-like members **364'** and **365'** at their distal ends. Shaft **364** is coupled through box **366** to a gearing arrangement **368,** which gear **368** is driven by shaft **370** which itself is driven by pulley **372** and associated belt **374** connected to a suitable driving motor. Shaft **365** is connected through box **376** to a rod and retainers **378, 380.** Shaft **365** will move in the rightward direction (with respect to FIGS. **20** and **21**) when rod **378** moves in the rightward direction. Referring to FIG. **21** in particular, it is seen that an arm **382** having a central pivot **384** is fastened at one end **386** to rod **378** and at the other end **388** to an elongated rod **390** which, when moved in the leftward direction (with respect to FIGS. **20** and **21**) will move arm **382** in a clockwise direction thereby pulling shaft **365** to the right, in order to release lens **30** or to permit insertion of a new lens blank **30.** A manual handle **392** is provided for enabling the operator to pull rod **390** in the leftward direction (with respect to FIGS. **20** and **21**).

It is seen that when the edge of a lens blank is to be polished, handle **392** is pulled in the leftward direction (with respect to FIGS. **20** and **21**) and lens **30** is inserted between cups **364'** and **365'** at which time handle **392** is released to urge cup **365'** against the blank **30** and force it into engagement with cup **364'.** The arm **382** is normally biased in the counterclockwise direction by means of a spring **396.**

The lens blank driving motor (not shown) is then actuated to move belt **374** and thus turn shaft **364** through gear **368,** while shaft **365** idles. Motor **338** and the motor (not shown) which drives wheel **346** are energized to provide arcuate movement of the polishing wheel **56.** The motor (not shown) connected to flexible shaft **400** which drives polishing wheel **56** is also energized to rotate wheel **56** while lens blank **30** is rotating and while the wheel **56** has imparted to it an arcuate motion with respect to the edge of the lens blank.

POWER CURVE POLISHING (FIGS. 24 and 25)

In the apparatus for polishing the power curve of lens blank **30,** the lens blank is held within recess **401** of member **403.** Member **403** defines a centralized recess **402** at its undersurface for receiving a rotatable shaft. A holder **404** is provided and defines a centralized recess **406** at its undersurface for grasping a polishing member **408,** which member is shown in detail in FIG. **25.** Holder **404** has an arm **410** which is pivotally connected to link **412** at pivot **414** so that holder **404** will rock in response to movement of link **412** in the direction of arrows *b.*

Referring to FIG. **25,** polishing member **408** comprises a member that is symmetrical about an axis *g—g* and includes a discshaped portion **416** and a crown portion **418.** FIG. **25** shows polishing member **408** in vertical cross-section. Member **408** has a concave undersurface **420** which has a radius of curvature that is slightly greater than the radius of curvature of a typical power curve of a contact lens blank.

It has been found that a most effective polishing member **408** can be obtained by forming the polishing

member from a soft wood, such as pine. The use of pine is advantageous because the wood is porous enough to become at least partially receptive to a liquid polishing compound, when member **408** is immersed into such a liquid polishing compound. When member **408** is connected to holder **404** and undersurface **420** engages the power curve of lens blank **30** during rotation of collet **401**, an effective polishing action is provided by the wood undersurface of member **408** engaging the plastic power curve and having the polishing compound that has been retained by member **408** acting upon the power curve of the lens blank.

It is preferred that the power curve be polished prior to polishing the edge of the lens, although in some instances the edging may occur prior to polishing the power curve.

Although an illustrative embodiment of the invention has been shown and described, it is to be understood that various modifications and substitutions may be made by those skilled in the art without departing from the novel spirit and scope of the present invention.

What is claimed is:

1. In apparatus for forming contact lenses, the improvement comprising, in combination: a cutting tool for cutting the base curve into a contact lens blank; means for positioning the cutting tip of said cutting tool in fixed working relationship with respect to said blank; means for providing relative rotation between the lens blank and the cutting tool; means for pivoting said cutting tool about a pivot point; and means for moving said pivot point to vary the radius of curvature of the base curve to be cut; wherein said cutting tip positioning means comprises a pivotable holder assembly defining a first slot, and a member located adjacent to said holder assembly and defining a second slot, said holder assembly and said member being positioned so as to permit said first and second slots to be aligned; said means for moving said pivot point comprising a first slider for sliding within said first slot and a second slider for sliding within said second slot, said pivot point being fastened to said first and second sliders.

2. Apparatus as described in claim **1**, including manually operable means for moving said second slider when said slots are aligned, to thereby force said first slider to move therewith; and means for preventing relative movement between said sliders and the aforementioned structure defining said slots.

3. Apparatus as described in claim **1**, wherein said member defines a first aperture, said pivotable holder assembly defines a second aperture which may be pivotally positioned in axial alignment with the first aperture, and means for coupling the first and second apertures to maintain alignment of said slots to permit precision movement of said pivot point.

4. Apparatus as in claim **1**, wherein said pivoting means comprises, in combination: a drive-wire secured to the pivotable holder assembly, a pulley for rotatably engaging the wire means, means for supporting said pulley, spring-biased pulley means secured to said support means for providing tension to said wire, follower means secured to said wire, a cam having an edge-surface for engaging the follower means, a motor for rotating said cam, and means to bias said follower means against the edge-surface of said cam.

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